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ABSTRACT

Hypothesis behavior on three dimensional concept attainment problems was measured for 48 children (12 each at grades K, 2, 4, and 6). Every feedback trial was followed by a blank trial, a procedure that provided separate measures of Ss' ability to use hypotheses and test hypotheses. A S was considered to be "using" when his hypothesis inferred from a blank trial was consistent with his choice on the next feedback trial. Given that a S was "using", he was considered to be "testing" when he correctly reevaluated his hypothesis following a feedback trial (win-stay, lose-switch). Young children did not use hypotheses as often as older children, and those who did use hypotheses tended to be less successful than older children in testing for validity. In particular, the youngest children were more likely to retain an incorrect hypothesis in spite of repeated negative feedback. Although younger children were less successful in reaching solution, those who did solve were likely to solve as fast as older children who solved. The usual dimensional preferences were not found: Children from each age group solved equally often using color, number, and shape dimensions. Experience with all three dimensions on the training tasks may have removed initial biases. (Author)

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Using and Testing Hypotheses in Concept Attainment by Children

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One of the most reliable findings in developmental studies of concept learning is that younger children do not perform as well as older children. A number of explanations have been offered for this effect. We will look at these interpretations as they relate to specific skills needed for efficient solving of concept identification (CI) problems. First, however, it may be useful to review briefly a typical CI paradigm.

In a typical simple CI task, stimulus patterns might consist of three dimensions, each of which can take on one of two values. For examples, one pattern might be a large red square and another pattern would be a small blue circle. The patterns can be assigned to one of two categories (e.g. "good guys" and "bad guys") by a simple rule chosen by the experimenter, such as all red figures are "good guys" and all blue figures are "bad guys". In the usual paradigm, the subject is shown one stimulus pattern at a time, he classifies it into one of the two categories, and then he is told whether he is right or wrong. The subject is said to have solved the problem when he is able to classify a series of patterns without error. There are many variations on the basic paradigm which might involve adding dimensions or presenting a pair of opposite patterns simultaneously and asking the subject to choose the "good guy".

Considerable evidence has accumulated to suggest that one common reason for poor performance by very young children is that they simply do not understand that there is a role to be learned. They tend to treat the task as a guessing game, and revert to primitive strategies like position perseveration or position alternation, strategies that ignore the stimulus values completely (Rieber, 1969; Weir, 1964). Thus the first requisite for efficient performance in a CI task is an understanding that there is a rule to be learned.

A second requisite skill is the ability to encode information from each of the dimensions in the stimulus patterns. It is common to find young children making responses that completely depend on a single cue, such as always choosing the red figure (e.g., Gholson, Levine, & Phillips, 1972). Information on all other dimensions is ignored, regardless of feedback. Kindergarten children, especially, are known often to have a strong preference for a particular dimension, such as form or color (Odom & Guzman, 1972). When a subject has a strong preference for one dimension he will have difficulty solving problems which use rules based on other dimensions (Johnson, Warner, & Silleroy, 1971; Suchman & Trabasso, 1966). A Piagetian interpretation might be that very young children do not have the "cognitive capacity" to change classification criteria. However, when children are given special training on identifying all the unidimensional concept rules and switching between them, performance on subsequent CI problems is greatly improved, and even kindergarten age children are able to use information from many dimensions (Schell, 1971).

A third skill needed for efficient performance is the ability to formulate hypotheses and respond the basis of these rules. As might be expected, younger children are less likely to respond consistently on the basis of a single hypothesis (Schonebaum, 1973). Such inconsistencies pose a special problem in experiments that use blank trial procedures to identify hypotheses.

Fourth, hypotheses need to be retained between feedback trials. Younger subjects are known to have poorer memory for stimuli (e.g., Schonebaum, 1973), and might be expected to have poorer memory for hypotheses as well.

Fifth, in order to solve CI problems efficiently, a subject needs to be able to test hypotheses. Testing a current hypothesis involves using

information from a new feedback trial to reject the hypothesis if it is not consistent with the new information and retain it if it is. Fewer young children are able to test hypothesis efficiently. One reason is that children sometimes tend to retain a favorite hypothesis even after it should be eliminated (Ingalls & Dickerson, 1969; Osler & Kofsky, 1966). Failure to eliminate hypotheses as soon as logically possible is a common error even for college students, but few college students will persist with a wrong hypothesis in the face of repeated negative feedback (Berger, 1974).

There are a number of skills, then, necessary for efficient CI. To evaluate higher level skills, it is necessary to ascertain that lower level skills are present. For example, if a child doesn't understand the nature of the CI task, it would be misleading to conclude that his poor performance is due to an inability to retain the correct hypothesis.

The current study was designed to permit evaluation of hypothesis behavior of young children. Subjects were given training to make sure that they understood the nature of the task and had experience using each of the dimensions in a solution. Separate indices were obtained for hypothesis using and hypothesis testing.

Method

Subjects. Six boys and six girls were randomly selected from each of grades kindergarten, 2, 4, and 6 in a Claremont elementary school, for a total of 48 subjects.

Stimulus Materials. Three decks of 18 stimulus cards were used to create problems at three levels of difficulty. A sample card from each deck is shown in Figure 1. The left section on each card contained a target

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Insert Figure 1 here

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pattern, and the right section contained three alternative choice patterns. Every pattern consisted of a combination of three dimension which took on one of three values: color (red, green, blue); number (one, two, three); and shape (circle, square, triangle). Each combination of values was prsented equally often and no cue values remained on the target for more than two cards in a row.

Problems. The subject's task was to learn the rule which would allow him to consistently point to the one response pattern that "goes best" with the stimulus pattern. A blank trial procedure (cf. Levine, 1966) was used wherein feedback was given on every other trial. Three problems were given from each deck, using each dimension for the rule once. There was a short break between problems and subjects were told to pretend they were starting all over on each new problem.

Note that problems from Deck 1 are quite simple, since only the relevant dimension is allowed to vary among the response patterns. The reason for including the three problems from Deck 1 was to teach subjects that the task was not a guessing game, but a rule could be found that would lead to perfect performance. Also, subjects learned that each of the three dimensions could be required in the rule.

The three problems from Deck 2 were more difficult, since one irrelevant dimension was allowed to vary in addition to the relevant dimension. The six problems from the first two decks were considered to be training problems. All children solved at least five of the six training problems within three feedback trials on Deck 1 and six feedback trials on Deck 2.

The three problems from Deck 3 were similar to typical CI problems in that all three dimensions were allowed to vary. A subject was considered to have solved a problem if the correct response pattern was chosen on the

last four of the total of nine feedback trials.

Some of the younger subjects required more than one session. Since they did not differ from other subjects their age on any measure, their data were pooled.

Results and Discussion. Solution rates on each of the three dimensions are presented in Table 1, with a breakdown by grade level and sex.

Insert Table 1 here

As expected, there is evidence that the older children solved more problems than the younger children. More of the children in the two older groups solved over half of the problems, $\chi^2(1) = 8.17$, $p < .01$. Although the girls did slightly better than the boys at each grade level, the six difference did not reach statistical significance, $\chi^2(1) = 1.35$, $p < .20$.

It is interesting to note that there is no apparent effect of which dimension was relevant to solution. Subjects at all ages solved equally well using each dimension. Since it is usually found that younger children find color and form to be more salient than number, and are more successful at solving problems using their preferred dimension, these data might be interpreted to mean that the training on each of the dimensions was successful.

The ability of subjects to use hypotheses was measured by the number of times the response choice on a feedback trail was consistent with the choice on the previous blank trial. On average, these children did very well, using hypotheses on .785 of the trials (Table 2). An analysis of

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Insert Table 2 here

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variance confirmed the grade level effect, $F(3,40) = 3.30$, $p < .05$. A post hoc Newman-Keuls test showed only the difference between 6th grade and

kindergarten children to be reliable. Again, girls tended to do better than boys, but the test for sex effect did not reach statistical significance.

Hypothesis testing involves retention of the current hypothesis following positive feedback (win-stay) and selection of a new hypothesis following negative feedback(lost-shift). Solution protocols consist entirely of win-stay responses after the trial of last error, so the ability of subjects to test hypotheses was measured by the proportion of times subjects shifted to a new hypothesis following negative feedback (lose-shift). Thus, the testing measure was taken only on occasions where subjects were using an incorrect hypothesis. The results are shown in Table 3.

Insert Table 3 here

An analysis of variance on the arcsine transformed proportions failed to detect any effects of grade level, $F(3,38) = 1.72$, $p < .10$. This lack of an age effect might suggest that once children are able to use hypotheses, their ability to test hypotheses is unrelated to age.

There is, however, an important qualification. One kind of testing error that young children are more likely to make is retention of an incorrect hypothesis in spite of repeated negative feedback. The proportion of times each subject retained an incorrect hypothesis following negative feedback was calculated, and a test of the median split of this proportion by age yielded $\chi^2(1) = 4.89$, $p < .05$. Of the ten subjects who retained an incorrect hypothesis more than half of the time, all ten were in one of the younger groups.

When analyses were performed separately on data from problems that were solved and not solved, there were no statistically significant differences across grade levels in the proportion of trials on which hypotheses

were used. Also, it was found that younger children did not differ from older children on the trial of last error on problems that were solved.

The picture that emerges, then, is that when children from grades Kindergarten to 6 are trained on the nature of a CI task and are given practice dealing with all the dimensions, problem solving ability depends largely on the ability to formulate hypothes of the sort that might lead to solution. Younger children have a special problem with a tendency to retain a favorite hypothesis even when it is wrong. However, younger solvers appear to be about as efficient as older solvers.

A final note is that it seems likely that instructions and training can critically affect relative performance of younger compared to older children. Nevertheless, one must demonstrate that subjects understand the nature of the task before inference can be drawn regarding higher level abilities.

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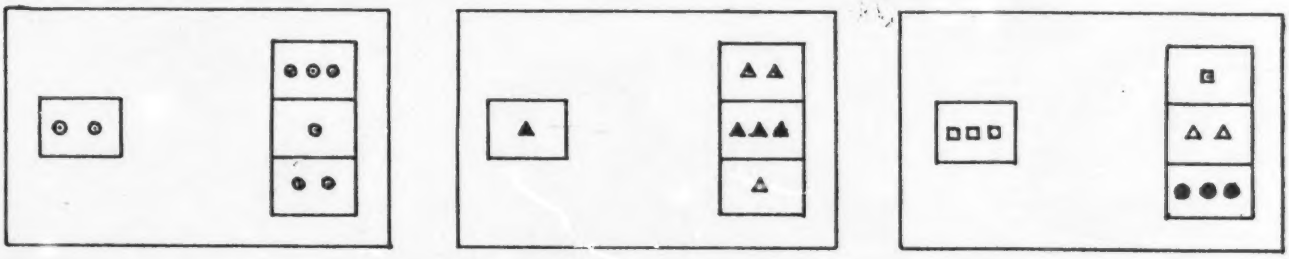

Figure 1. A sample card from each of the three decks.

o-red
o-green
•-blue

Table 1. Number of problems solved by dimension, grade level, and sex.

	Grade Level								Totals		
	K		2nd		4th		6th				
Dimension	boy	girl	boy	girl	boy	girl	boy	girl	boy	girl	total
Color	2	3	4	4	4	6	2	5	12	18	30
Number	2	3	2	5	4	4	3	4	11	16	27
Shape	2	2	2	3	3	4	5	3	12	12	24
Totals	6	8	8	12	11	14	10	12	35	46	81
	14		20		25		22				

Table 2. Proportion of trials on which hypotheses were used by grade level and sex.

	Grade Level				
	K	2nd	4th	6th	Ave.
Boys	.630	.765	.741	.858	.748
Girls	.741	.846	.846	.852	.821
Average	.685	.806	.793	.855	.785

Table 3. Proportion of shifts to new hypotheses given an error on current hypothesis by grade level and sex.

	Grade Level				
	K	2nd	4th	6th	Ave.
Boys	.232 (n=6)	.561 (n=6)	.535 (n=6)	.590 (n=6)	.479
Girls	.286 (n=6)	.458 (n=6)	.394 (n=5)	.647 (n=5)	.440
	.259	.509	.471	.616	